NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

ECONOMIC ASPECTS OF AIRPORT SECURITY MEASURES

by

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June 1999

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 1999	Master's Thesis

4. TITLE AND SUBTITLE : Economic Aspects of Airport Security Measures

5. FUNDING NUMBERS

6. AUTHOR(S)
Santos, Alvaro K.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(maximum 200 words)***

Airport security measures use very expensive equipment, and may keep passengers in line for several minutes. The time passengers spend in those lines can add up, and must be understood as time opportunity cost. In the 1970s, several airport security measures were adopted to help stop aircraft hijackings. In 1978, William M. Landes wrote the paper "An Economic Study of the U.S. Aircraft Hijacking, 1961-1976", in which he analyzed the expenditures associated with airport security measures. He concluded that the costs of the adopted measures were very high. While Landes concentrated on the monetary costs of airport security, this thesis concentrates on the estimating the opportunity costs of airport security measures for passengers – their losses in terms of their time value. This thesis estimates that the hijacking-preventing impact of airport screening measures is insignificant, but the opportunity costs these measures impose on airline passengers are significant and greatly exceed the benefits produced.

14. SUBJECT TERMS
Airport Security, Aircraft Hijackings, Aircraft Bombings, opportunity cost, time value, policy analysis.

15. NUMBER OF PAGES
82

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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ECONOMIC ASPECTS OF AIRPORT SECURITY MEASURES

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June, 1999

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ABSTRACT

Airport security measures use very expensive equipment, and may keep passengers in line for several minutes. The time passengers spend in those lines can add up, and must be understood as time opportunity cost. In the 1970s, several airport security measures were adopted to help stop aircraft hijackings. In 1978, William M. Landes wrote the paper "An Economic Study of the U.S. Aircraft Hijacking, 1961-1976", in which he analyzed the expenditures associated with airport security measures. He concluded that the costs of the adopted measures were very high. While Landes concentrated on the monetary costs of airport security, this thesis concentrates on the estimating the opportunity costs of airport security measures for passengers -- their losses in terms of their time value. This thesis estimates that the hijacking-preventing impact of airport screening measures is insignificant, but the opportunity costs these measures impose on airline passengers are significant and greatly exceed the benefits produced.

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I. INTRODUCTION

A. BACKGROUND

In the United States, every year millions of passengers use air transportation to travel from one place to another. They all are subjected to airport security measures, including metal detectors, X-ray scans of both hand-carried and checked luggage, and check-in counter questioning about passengers' knowledge and control of their baggage.

All these airport security procedures demand extra time from passengers. If we consider individuals with higher income to be the most common air travelers, and that these passengers assign a high value to their time, we can conclude that airport security measures must represent a significant cost in terms of passengers' time value. It is reasonable to consider this cost when calculating the total cost of airport security measures.

The government is another major player in this issue. Most airport security equipment is acquired, maintained, disposed, and replaced using budgetary appropriations. In addition, public funds pay for most of the extra personnel needed to operate and maintain airport security equipment, as well as for those who enforce the security measures.

All the costly airport security measures we see today were adopted to prevent criminal interference with aircraft, namely aircraft hijacking and aircraft bombing.

1. Aircraft Hijacking.

According to William M. Landes[1] (1), the first aircraft hijacking in the United States ocurred on May 1st 1961: An airliner en route from Miami to Key West was hijacked and diverted to Cuba. Between 1962 and 1967 eight additional aircraft were hijacked. In most cases, they were diverted to Cuba.

Between 1968 and 1972, the number of hijacking occurrences surged to 124, most of which were also diverted to Cuba.

Landes further reports that the number of aircrafts hijacked in the United States fell dramatically after 1972.

Landes states that many modern airport security measures were introduced in the seventies. These measures increased the probability that an offender would be caught. The newly introduced security measures were a powerful hijacking deterrence factor, but the cost of such measures was "enormous" (Landes page 28).

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1 - Landes, W.M., "An economic study of U.S. Aircraft hijacking, 1961-1976", Journal of Law and Economics, volume 21, 1978.

It is interesting to consider now another piece of data that Landes reports in the third footnote of the first page of his paper:

> Even during the peak year 1969, however, the probability that an aircraft would be hijacked on any given day in the United States was negligible ($=0.7 \times 10^{-5}$). Yet this was more than 500 times greater than the probability that an individual would be murdered on a given day ($= 0.2 \times 10^{-6}$).[2]

If the probability that a person will be murdered in a given day is one thirty-fifth of the already negligible probability that an aircraft would be hijacked on a given day, the likelihood that a person will be killed while kept hostage during a aircraft hijacking is even more negligible.

In face of the low probability that a given flight is going to be hijacked, it is necessary to verify whether the benefits of airport security measures are economically adequate to justify the associated costs.

2. Aircraft Bombing

After the explosion of TWA flight 800, President Bill Clinton ordered a significant increase in airport security measures in the United States. President Clinton's stated objective for increasing security measures was to further reduce the probability of terrorism. These are costly

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2 - If we do the mathematics, we will realize that the probability that an individual would be murdered on a given day really is thirty-five times smaller than the probability that an aircraft would be hijacked on a given day, and not five hundred times smaller, as Landes wants us to believe.

measures that mostly focus on screening a greater number of passengers, cargo, and luggage.

Interestingly enough, nobody has yet determined what provoked the explosion that destroyed flight 800. Among the plausible causes considered, only the explosion of a bomb inside the aircraft or a missile hitting the aircraft could be fruits of terrorism. Again, no evidence has confirmed any of the possible causes, including terrorist activity.

In the article "TWA Flight 800: The mystery remains,"[3] Jim Kallstrom, FBI deputy director, states:

> We looked under every rock five times;...We left no aspect of this investigation uninvestigated. We did the most thorough, totally comprehensive investigation we can. And, ladies and gentlemen, it's our belief, to a high certainty, that this plane was not brought down by a bomb, a missile, or some device.

Despite the inconclusive investigation about what happened to TWA 800, the government is sponsoring vice-president Gore's $1.1 billion (1996 dollars) enhanced security program[4].

No evidence has proven terrorism caused the explosion that destroyed TWA 800. After the bombing of the Pan Am 103 in Scotland in 1989, no other American airliner has been

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3 - Bayles, F. and Davis, R.,"TWA Flight 800: The mystery remains", USA TODAY, July 11th 1997.

4 - Lane, E., "$1.1B requested to combat terror", NEWSDAY.COM (URL: http://www.newsday.com/jet/twamain.htm),September 10th 1996.

bombed. So, it is valid to question the basis for enacting President Clinton enhanced security program, and whether the benefits of these measures economically justify the costs.

B. OBJECTIVE

The objective of this study analyzes the costs and benefits of the United States government's policies to prevent and deter airplane hijackings and bombings. It determines whether the total additional costs are economically balanced with the benefits they bring.

C. THE RESEARCH QUESTION

The research data collected to support this study answers the question: what are the costs and benefits of investing in airport security?

D. SCOPE AND LIMITATIONS

1. Scope

This thesis is limited to studying the economic aspects of airport security measures. Specifically, the costs of airport security measures are compared to their economic benefits for the nation.

2. Limitations

Only non-classified data are used here. In the case that a given policy or security measure involves classified objectives or benefits, these classified aspects are not considered when comparing policy's benefits to its costs.

E. LITERATURE REVIEW AND METHODOLOGY

William M. Landes' paper "An economic study of U.S. aircraft hijacking," Journal of Law and Economics, volume 21, 1978, is the point of origin for what is discussed here.

Landes' study raised questions that are still relevant to understanding the economic balance between costs and benefits of government airport security policies.

F. ORGANIZATION OF THE STUDY

1. Chapter II

An analytic framework is presented. It specifies the theoretical standard for economically justified government policies concerning airport security measures.

2. Chapter III

Landes' conclusions are expanded by the additing passenger time value data. The new data are used to evaluate how much passengers would really be willing to pay to avoid being hijacked, assuming the probability of being hijacked is, according to Landes (1), negligible.

3. Chapter IV

The costs and the benefits are estimated for the Clinton Administration's airport security measures proposed after the explosion of TWA 800.

The benefits -- the value of the aircraft hijackings avoided or deterred -- are compared to the government

budgetary costs of such measures, and to the passengers' costs in terms of their time value.

4. Chapter V

Conclusions are drawn from the discussion in the previous chapters.

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II. ANALYTIC FRAMEWORK

A. REVIEW OF LANDES' PAPER

As mentioned before, William M. Landes wrote the paper "An Economic Study of US Aircraft Hijacking, 1961-1976," published by the JOURNAL of LAW AND ECONOMICS, volume XXI, 1978.

At the beginning of his paper, Landes presents some interesting data concerning aircraft hijacking in the U.S. and worldwide. The Table below shows some of these numbers.

PERIOD	NUMBER OF AIRCRAFT HIJACKINGS	
	INSIDE THE US	OUTSIDE THE US
1961 to 1967	8	19
1968 to 1972	124	174
1972 to 1976	11	56

Table 1 - Number of Aircraft Hijackings in the U.S. and in the World[5]

Inside and outside the United States the pattern of aircraft hijacking occurrences is similar. Both had an initial period with few hijackings, followed by a surge in cases.

Interestingly enough, this surge occurred between 1968 and 1972 in both cases. After that, the number of aircraft

5 - Data collected from the Table in page 3 of Landes' paper.

hijackings decreased significantly, both in the United States and worldwide.

Although Landes showed data of aircraft hijackings both inside and outside the U.S., his study focused mainly on aircraft hijackings inside the United States.

Landes writes that, until 1971, either for political reasons or to avoid prosecution for crimes committed in the United States, Cuba was the preferred destination of the hijackers of U.S. aircrafts.

From Table 1 above, we are confronted with the same question that puzzled Landes: "What accounts for the dramatic reduction in U.S. hijacking after 1972, and how does one explain the pattern of hijackings in general?" (Landes page 2)

Landes raised two possible explanations for the pattern of behavior and timing of aircraft hijackings in the United States and worldwide. The two possible explanations are the deterrence hypothesis and the fad hypothesis.

1. Deterrence Hypothesis.

Landes hypothesized that introducing airport security measures increased the likelihood of capturing hijackers, and decreased hijackers' expected benefits. The Table below shows the number of offenders captured during each of the periods considered.

PERIODS	NUMBER OF OFFENDERS		PERCENT OF OFFENDERS APPREHENDED WITHIN 12 MONTHS	
	INSIDE THE US	OUTSIDE THE US	INSIDE THE US	OUTSIDE THE US
1961 to 1967	10	92	80 %	45 %
1968 to 1972	168	443	41 %	42 %
1972 to 1976	15	108	100 %	66 %

Table 2 - Number of Hijackers and Percentage of Hijackers Apprehended in 12 Months[4]

During the surge period between 1968 to 1972, the likelihood of apprehension was well below 100%, both inside and outside the United States. After that, the likelihood of apprehending offenders increased substantially, especially inside the United States.

According to Landes' deterrence hypothesis, two major types of airport security measures contributed to deter aircraft hijackings, either by decreasing the probability that the hijacker would be successful, or by reducing the probability of benefiting from the offense: deterrence and inspection measures.

The first type of measures was the deterrence measures. These measures fight hijackings when they happen, and reduce the benefits for the hijackers.

The second type of measures is inspection measures, also called screening measures. These measures make it more difficult for hijackers to bring weapons and other needed materials to planes.

The deterrence model states that introducing deterrence and inspection measures during the seventies was the most important factor increasing the probability that an offender would be captured within the first 12 months after the hijacking. The higher probability of capture should help prevent aircraft hijackings. (Landes, page 2)

The consequence of being apprehended is the penalty imposed on offenders. An adaptation on Landes' prison sentencing data is portrayed in the Table below.

PERIOD	AVERAGE SENTENCE (YEARS)
1961 to 1967	10.15
1968 to 1972	10.20
1972 to 1976	23.01

Table 3 - Average Sentence of the Hijackers

This Table verifies that the sentences for aircraft hijacking in the United States -- the average number of imprisonment years imposed on defendants -- more than doubled.

According to Landes' deterrence hypothesis, increasing the probability of capturing aircraft hijackers in the U.S. after 1972, and the severity of the penalties imposed when captured should play an important role in explaining the pattern of aircraft hijackings over time.

Landes mentions two accessory factors to the deterrence model. The first is that offenders began to run the risk of being killed during the hijacking.

Landes notes that before 1971 no offender was killed while hijacking an aircraft (page 4). After that, however, more than ten percent of the offenders were killed by law enforcement agents.

The second factor is that Cuba lost its appeal as a hijacker sanctuary. According to Landes, this process began when the way hijackers were treated in Cuba became known in the United States.

Cuba became more unpleasant for hijackers in 1973, when the United States and Cuba signed and enforced a treaty to extradite and punish hijackers.

Landes built a regression model to verify the deterrence hypothesis. He found that the explanatory power of the variables used was high enough to make deterrence the most probable explanation for the time pattern of aircraft hijackings.

The numbers below were extracted from Table 3 on page 13 of Landes' paper. They show the regression results Landes obtained from his model.

Independent Variables	Coefficient	t-value
Proportion of hijackings in which the offenders were apprehended	-10.958	2.961
Probability of incarceration	-4.742	0.998
Average sentence	-0.082	1.580
Proportion of offenders killed	-2.347	1.212
Unemployment rate of civilian labor force	1.204	2.056
Population	0.870	1.210
Per capita personal consumption	9.717	1.136
Time	-0.480	1.028

Table 4 - Coefficient and T-Values of the Variables of Landes' Deterrence Model.

2. Fad Hypothesis

Landes' second possible explanation (page 2) is the hypothesis that aircraft hijacking was nothing more than a fad that lost momentum in 1972. This means that aircraft hijacking would have faded away on its own after it lost its momentum.

If this is the true explanation behind the time pattern of aircraft hijackings, expensive airport security measures are pointless.

Landes believes (page 16) that this view greatly underestimates the deterrence power of airport security measures. He states this clearly when he writes:

> Implicitly, this approach rejects or greatly discounts the importance of changes in the probability of apprehension and other measures of deterrence to explain the hijacking time series. Thus, the fad hypothesis would interpret the negative association between deterrence variables and hijackings in Tables 3 and 4 as due to a coincidence between changes in deterrence levels and the intensity of the hijacking fad. (Landes, page 16)

Landes suggests that if aircraft hijacking was a fad, "the U.S. deterrence variables have about the same impact and degree of significance on the foreign variables as they do on U.S. hijackings."(page 17)

To test the fad hypothesis, Landes ran his regression model using foreign hijackings as an independent variable.

He concluded that, with the exception of the probability of incarceration, all variables showed coefficients and t-values comparable to those of the regression model considering only U.S. hijackings.

Landes' regression results, extracted from Tables 3 and 5, on pages 13 and 17 of his paper respectively, are summarized in Table 5 below:

Independent Variables	Without Foreign hijackings		Including foreign hijackings	
	Coefficient	t-value	Coefficient	t-value
Proportion of hijackings in which the offenders were apprehended	-10.958	2.961	-11.140	3.309
Probability of incarceration	-4.742	0.998	-5.153	1.192
Average sentence	-0.082	1.580	-0.081	1.715
Proportion of offenders killed	-2.347	1.212	-1.909	1.081
Foreign hijackings	***	***	0.265	3.381

Table 5 - Comparison of the Coefficients and T-Values of the Variables of the Regression Model Including and not Including Foreign Hijackings.

Although the t-value of the variable "foreign hijackings" is highly significant when used as independent variable, Landes (page 18) considered that it remained ambiguous considering the t-values of the deterrence variables.

Further considering the fad hypothesis, Landes suggests that if aircraft hijacking were a fad, U.S. deterrence variables should have significant negative effect on foreign hijacking (page 18).

However, Landes (page 18) discovered that the four deterrence variable coefficients were statistically significant and two of them were positive. Here are his numbers extracted from Table 5 on page 17 of his paper:

Independent Variables	Coefficient	t-value
Proportion of hijackings in which the offenders were apprehended	0.684	0.113
Probability of incarceration	1.546	0.199
Average sentence	-0.004	0.047
Proportion of offenders killed	-1.649	0.519

Table 6 - Coefficients and T-Values When Foreign Hijackings are the Dependent Variable.

After testing both the deterrence and the fad hypotheses, Landes was left only with deterrence from the additional security measures introduced in the seventies to explain the sharp decline in the number of aircraft hijackings in the United States after 1972.

Landes next considered the costs of the new security measures. Landes found that these costs had two elements: the equipment costs of the security systems and the costs to the passengers affected by the security measures.

Landes' only data about security equipment costs involved 1974 expenditures on airport security. Landes

assumed that the same amounts were spent on airport equipment in 1973, 1975, and 1976.

After deducting the decrease in costs of the old security measures that were replaced by the new ones, Landes (page 25) estimated a $194.24 million (1974 dollars) net increase in the costs of airport security measures during the period from 1973 to 1976.

The second cost element for airport security measures involves the costs to passengers in terms of their time value. However, Landes did not consider this cost. He explains:

> Unfortunately, I have no information on these indirect costs and thus the analysis that follows only considers the net increase in monetary costs of the screening program. (Landes, page 25)

Landes combined the data on costs he obtained, which exclude the indirect costs of airport security measures, with the data from the deterrence model regression equation of the deterrence model.

He concluded that between 1973 and 1976 the average cost of deterring a single hijacking was between $4.74 and $9.25 million (in 1974 dollars).

According to Landes (page 26), between 1973 and 1976, the newly introduced security measures reduced the probability that a given aircraft would be hijacked in the

United States by a value between 0.000003449 and 0.000001207.

In the footnote two on page 1 of his paper, Landes estimated that the probability that a given aircraft would be hijacked in the United States on a certain day is 0.000007. From this probability and the numbers given above, we can conclude that the adopted security measures reduced the probability that a given aircraft would be hijacked on a given day by between 17.24% and 49.27%.

Landes (page 26) further estimates that, during the period mentioned, the reduction in the probability that an aircraft would be hijacked imposed a cost of approximately $26.46 on each enplaned passenger in the United States.

Again, these values do not include the indirect costs of the introduced security measures.

Landes' (page 26) concludes that $26.46 per person to avoid being hijacked would be justified only if the individual hijacking loss were between $76,718 and $219,221 (1974 dollars). According to Landes, the cost of increased security exceeded the expected benefits, even though the security measures were highly effective in preventing hijackings. (page 29)

B. WHAT ARE GOOD GOVERNMENT POLICIES CONCERNING AIRCRAFT HIJACKING PREVENTION

According to Harvey S. Rosen, "the mechanistic view of the government has come to dominate Anglo-American political thought."[6] Rosen explains that under this view, the government is "a contrivance created by individuals to better achieve their individual goals," and that "The individual rather than the group is at the center of the stage." (Rosen, page 5)

Rosen believes that societies where the mechanistic-view prevails think their governments exist to protect individuals from all kinds of violence. (Rosen, page 5)

Even those in American society who do not embrace the mechanistic view of the government might want the United States Government to protect its citizens from violence, including aircraft hijacking.

Governments, however, have to finance their actions by taxing their citizens. The United States government has to use tax revenues to finance its deterrence measures against aircraft hijacking, and to enforce its anti-hijacking policies. This can be understood as the direct cost of government actions against aircraft hijacking.

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6 - Rosen, Harvey S.: Public Finance, 5th ed: Irwin/McGraw Hill, 1998, p. 5

Government actions against aircraft hijacking also may have an indirect cost component. This happens when the government makes a policy where implementation requires that airport administrations and airlines spend money to comply with the new policy.

When the government's policies impose indirect costs on airports and airlines, it is only logical to expect that these entities will largely pass this financial burden along to users, to the maximum extent possible considering the elasticity of the industry demand and supply curves.

If government actions against aircraft hijacking can hit airport security users' pockets via taxation and the elevation of the prices of air transportation-related activities, it is very important to realize what would be good government policies.

It is possible to evaluate government policies concerning airport security through the analysis of the facts and criteria discussed below.

1. The benefit of any increase in airport security must exceed its related costs

If the government makes a policy to increase airport security, it is only fair to require that the increment in costs is at least equal to the additional benefits it brings to users.

The common sense tells us not to pay for something that costs more than the expected benefits.

2. Users pay for increases in security

Even if government policies concerning airport security could be produced at zero cost to the users, there will be definite costs to implement these policies.

Airports and airlines will not bear all costs of complying with the new policies, but they will pass a portion of these costs along to users, as the market elasticity allows them.

In addition, new airport security policies involve increased costs for passengers in terms of their time value.

Thus, it is important that the society only supports those government policies to increase airport security, which generate known additional costs, and for which the costs are no grater than the additional benefits those policies bring.

3. All objectives of the new security policies must be known

When the government chooses to make a new policy concerning airport security it has objectives it whishes to achieve.

Landes (page 29) found that the adopted airport security measures, though highly effective in deterring aircraft hijackings, cost between $3.24 million to $9.25

million (1976 dollars) per deterred hijacking. He considered this cost excessive compared to the benefits these expenses provide to air transportation users.

Landes calculates that the costs of these measures would be justified only if the individual benefit for each passenger that avoids hijacking were in the range of $76,718 to $219,221, in 1996 dollars.

If the visible costs are so much higher than the increase in passenger security, there must be other objectives, whose achievement is not clearly stated in the policy.

To support objective analysis, government policies must clearly state all their objectives. If the costs of a policy exceed its stated benefits, that policy must be changed or abandoned.

4. Airport security policies must not be justified by the jobs they create

When the government establishes airport security policy, it must only consider the users' needs. Objectives such as creating new jobs to increase employment are inappropriate.

Job creation is more appropriately addressed through macroeconomic policies. Furthermore, creating new jobs automatically generates the need to pay the associated

salaries. This additional cost is largely borne by the users of the airport security measures.

When an airport security policy creates new jobs, but the cost of these jobs is not offset by the benefits produced, that policy should be changed or abandoned.

5. Policies concerning airport security may have unintended consequences

Governments can not foresee all the consequences a new airport security policy will generate. Normally there are some unintended consequences. If unintended benefits are generated, the user will be better off. But if unforeseen costs are incurred, users may be worse off than before.

Government airport security policy should be changed or abandoned if its foreseen and unforeseen incremental costs to users exceed the additional users' benefits, foreseen and unforeseen.

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III. COSTS VERSUS BENEFITS OF AIRPORT SECURITY MEASURES

This chapter compares the costs of airport security measures during 1996 to the benefits for that year's passengers. Landes' paper will be used as initial reference.

Landes (page 29) concluded that the cost of the mandatory screening program was "enormous." The costs he estimated were the financial costs of implementing the mandatory screening policy in American airports.

Besides the financial costs, there are opportunity costs to passengers: they spend extra time in airports waiting for and processing through screening. It is important to estimate those costs and compare them to the benefits screening provides air transportation passengers. The year 1996 was chosen because it is the most recent year for which all needed data is available.

The analysis in this chapter includes three steps. The first is to estimate the hijackings deterred in 1996. The second estimates how people value their time, to estimate the opportunity cost of time spent going through airport security in 1996. The third step compares the passenger's costs and benefits of those measures.

A. HOW MANY HIJACKINGS WERE DETERRED IN 1996?

How many aircraft would have been hijacked in the U.S.

if passenger-screening measures were not in place during 1996?

Landes' data was collected for his full deterrence regression model. Landes' complete model is not used in this thesis because gathering the required data was beyond the scope of this thesis.

Despite this, a simplified regression model was designed. This model's estimated number of hijackings is not accurate enough to be used as an estimate in this thesis, but it indicates the impact of passenger screening alone in preventing hijackings. The data used in this model include:

1. The number of aircraft hijackings that occurred in the United States in each month between 1961 and 1977.[7]
2. The number of passengers enplaned in the United States during this period.
3. The associated number of commercial airline departures.
4. The number miles flown by commercial airlines in the given period.
5. The date when the United States and Cuba signed a

7 - Obtained in the 1986 FAA report.

treaty to exchange and punish aircraft hijackers.[8]

6. The date when the anti-hijacking bill passed in the United States Senate, and pre-boarding passenger screening was introduced.[9]

The dates in items 5 and 6 above separate the deterrence impact of these two events in the forecasted hijackings. A dummy variable was used for each event.

The dummy variable for "treaty" has the value zero before the treaty was signed (January 1961 to February 1973), and the value one afterwards (March 1973 to December 1977).

The dummy variable for "passenger screening" has the value zero before screening was introduced (from January 1961 to February 1972), and value one afterwards (March 1972 to December 1977).

The data used in the regression model is displayed in Appendix A.

The following results were obtained after first running the regression model:

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8 - Kavass, Igor I.:UNITED STATES TREATY INDEX, Vol. 8, William S. Hein & CO. Inc., NY,1985.

9 - The New York Times Bank of Abstracts, 1972. It was used the first date when airport security measures were required to comply with President Nixon's government directives, because the effective date of introduction of the measures varies from airport to airport.

Variable	Coefficient	t-value
Constant	-1.92	-1.74
Number of passengers	0.00020479	2.97
Number of departures	0.00000217	0.48
Number of miles flown	-0.00000001	-0.11
Treaty with Cuba	-2.1669	-4.76
Passenger screening	0.0335	0.07

Table 7 - Results of the First Regression Run.

The t-values show statistical significance for the constant and the coefficients on the variable "number of passengers" and on the dummy variable for "treaty with Cuba."

However, the coefficients on the variables for "number of departures", "number of miles flown", and "passenger screening" are statistically insignificant.

In the subsequent regression run the variables "number of departures" and "number of miles flown", whose coefficients are statistically insignificant, were dropped. Even though the coefficient on the dummy variable for "passenger screening" is insignificant, the variable was not dropped.

The results of the modified regression model are shown below.

Variable	Coefficient	t-value
Constant	-1.4143	-4.68
Number of passengers	0.00023499	8.49
Treaty with Cuba	-2.2657	-5.62
Passenger screening	-0.0401	-0.10

Table 8 - Results of the Second Regression Run.

In this second run, the t-values increased for the

constant, and for the coefficients on the variable "number of passengers" and the dummy variable for "treaty with Cuba." The coefficient on the dummy variable for "passenger screening" still has an insignificant t-value.

The statistical insignificance of the coefficient on the dummy variable for "passenger screening" should not be surprising. Hijackers can substitute conventional weapons for other weapon types that metal detectors or X-ray scanners can not detect. For example, X-ray scanners can not detect synthetic-material guns.

The insignificance of screening is also evident when the coefficients above are applied to 1996 data (Appendix B).

To estimate the impact of passenger screening on the number of hijackings in 1996, that year's data was applied to the model twice. In the first application, the dummy variable for "passenger screening" has value one; in the second application "passenger screening" has value zero.

When value one is assigned to the dummy variable for "passenger screening," the model considers the impact of passenger screening on the predicted number of hijackings in 1996. This predicted number is 91.87 occurrences.

When value zero is assigned to the dummy variable for "passenger screening," the model does not consider the

impact of passenger screening in predicting hijackings in 1996. This predicted number is 92.35 occurrences.

As stated before, the regression model used to estimate these predictions was not particularly accurate. The adjusted R^2 value was 32.5% and the predicted number of hijackings considering the impact of screening -- 91.87 occurrences -- was very different from the actual number of hijackings in 1996 -- zero.

Nevertheless, the striking thing about the predicted values, with and without screening, is how close they are -- both round to 92. Thus, this imperfect model suggests that the actual number of prevented hijackings in 1996 was zero.[10]

Because the model is imperfect, another way to estimate how many hijackings screening prevented is to assume, independently of the research findings above, that screening was highly effective.

Landes called the period between 1968 and 1972 the "peak years." On average, there were 29 hijackings annually during this period. The assumption is that the average number of hijackings without screening grows with the number of passengers.

Considering that the average annual number of

10- Statistical Abstract of the United States, 1997.

passengers between 1968 and 1972 was approximately one third of the number of passengers in 1996, this assumption indicates that 87 hijackings would have occurred in 1996 if the security measures had not been in place. This number certainly overestimates of the number of hijackings prevented in 1996.

B. HOW VALUABLE IS THE INDIVIDUAL TIME

Besides the portion of the airport security costs included in the price of air transportation tickets, passengers bear time costs by waiting in line to go through security measures.

There is no perfect way to calculate an individual's real time value. However, calculating an individual's time value is critical to this chapter's objective.

At some moment in our lives we have all heard the expression "time is money." Everybody would agree that time is worth something to every person. However the problem is in calculating a monetary value for this "something."

Harvey S. Rosen, in Public Finance,[11] notes that a common approach to this problem is to exploit leisure-income choice theory. Rosen explains:

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11 - Rosen, Harvey S.: Public Finance, 5th ed: Irwin/McGraw Hill, 1998.

> People who have control over the amount they work do so up to the point where the subjective value of leisure is equal to the income they gain from one more hour of work -- the after-tax wage rate. Thus, the after-tax wage rate can be used to value the time that is saved. (Rosen, page 236 to 237)

Continuing in his exposition, Rosen (page 237) presents two major problems with this approach. The first problem is that not all people can choose the amount of time they work. This is especially true when one's work contract requires the person to work a fixed number of hours per week.

People who work under this kind of contract have little or no control over the number of hours they work in a day or in a week. Thus they do not have many opportunities for making the kind of choice addressed in income-leisure theory. According to Rosen, (page 237) unemployed people are the "extreme example" of this first problem.

The second problem Rosen (page 237) mentions is that time away from the job is not used equivalently. Rosen writes:

> For example, to avoid spending time on the road, a person who hated driving might be willing to pay at a rate exceeding his wage. On the other hand, a person who used the road for pleasure drives on weekends might not care very much about the opportunity cost of time, particularly if she could not work on weekends anyway. (Rosen, page 237)

Rosen (page 237) writes that regardless of the existence of people that "cannot choose their hours of

work," and that "not all uses of time away from the job are equivalent," it is possible to estimate time value. According to Rosen, some researchers estimate people's time values by observing their transportation choices across modes that have different traveling times and prices. In the studies to calculate the value of an individuals' time, observing the extra money people are willing to spend to reduce their commuting time reflects how much each person values his or her time.

Rosen (page 237) concludes, based on these studies, that "a reasonable estimate of the effective cost of traveling time is about 50 percent of the before-tax wage rate."

This approach is used to calculate the opportunity cost for passengers, that is the value of the time they spend waiting to go through airport security measures.

C. THE VALUE OF TIME FOR 1996 AIR TRANSPORTATION PASSENGERS

To use Rosen's method to calculate the passenger's time value is necessary to estimate their before-tax incomes. The most updated data available is from the October 1997 edition of the "American Travel Survey."[12] The data below can be found in Figure 8 on page 8 of that survey:

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12 - Bureau of Transportation Statistics: "American Travel Survey", U.S. Department of Transportation, Oct/97. URL - http://www.bts.gov/programs/ats/corepage.html.

Income (thousands)	Percent of the number of person trips
More than $50	65.50%
$25 to $50	24.80%
Less than $25	9.70%

Table 9 - Percent of Personal Trips per Income Bracket.

The percentages above reflect 1995 travel data. This analysis assumes that the percentages were the same in the following year, 1996. Furthermore it is assumed that the income brackets shown in Table 7 refer to before-tax income; the "American Travel Survey" does not specify the income reported.

The section Data & Statistics, Passengers Enplaned, of the "Air Transport Association"[13] report listes the number of passengers enplaned since 1960 in both domestic and international flights. For 1996, the total figure is 581.2 million passengers.

Applying the percentages in Table 7 to the total enplaned passengers in 1996, estimates the 1996 air trips taken by persons in each of the different income brackets. The results are in Table 10 below.

Income (thousands)	Percent of the number of person trips	Number of trips (in millions)
More than $50	65.50%	380.7
$25 to $50	24.80%	144.0
Less than $25	9.70%	56.3
	100.00%	581.2

Table 10 - Number of Trips per Income Bracket in 1996. The Numbers do not Add Up Exactly Due to Rounding Error.

13- Air Transport Association: "Data & Statistics", URL: http://www.air-transport.org/data/traffic.htm

According to Rosen (page 237), a person's time value can be estimated as 50% of his or her before-tax wage rate. It is necessary to estimate each individual's wage rate to perform a precise calculation.

Statistical research to estimate the true average-hourly wage rate for each of the income brackets is outside of the scope of this thesis. The costs and benefits of airport security measures, however, can be compared using conservative estimates for wage rates.

The following assumptions were made to estimate hourly wage rates from the data above:

1. All income brackets refer to before-tax income.
2. The daily wage rate was calculated dividing the annual wage rate by 260 days. The hourly wage rate was calculated dividing the daily wage rate by 8 hours.
3. The mean annual wage rate in the two lower income intervals is equal to the arithmetic average between their limits.
4. Estimating the mean annual income for the higher income bracket is more difficult; there is no upper bound to use in calculating an average wage. This analysis uses a conservative estimate that underestimates these wages. Thus, it was assumed

that the mean annual salary for the highest income interval equals $100,000.

Income	Mean annual wage rate	Mean hourly wage rate	Time Value of One Hour
More than $50	$100,000	$48.08	$24.04
$25 to $50	$37,500	$18.03	$9.01
$0 to $25	$12,500	$6.01	$3.00

Table 11 - Hourly Wage Rates in the Different Income Intervals.

The time values shown in Table 12 were calculated dividing the hourly wage rate by 2, according to Rosen's conclusion that the opportunity cost of time is half of the before-tax wage rate.

The estimated the mean time value for passengers in the different income brackets can be used to estimate their opportunity cost for the two-minute delay to wait for an complete airport screening measures.

Income (thousands)	Time Value - one hour	Time Value - one minute	Number of trips (millions)	Cost of waiting two minutes in line (in millions of dollars)
More than $50	$24.04	$0.40	380.7	$305.1
$25 to $50	$9.01	$0.15	144.0	$43.3
$0 to $25	$3.00	$0.05	56.3	$5.6

Table 12 - Cost of Waiting 2 Minutes in Line.

If each passenger in 1996 waited two minutes to complete the security measures, the opportunity cost of time for airport security would equal approximately $354.0 million dollars (1996 dollars).

D. COSTS VERSUS BENEFITS OF SCREENING MEASURES

The data in the previous sections can be used to estimate the cost to deter a single hijacking in 1996, in terms of the time value for passengers in 1996.

There is a good case to be made, based on earlier regression results, that airport screening did not prevent any hijackings. If this is true, 1996 passengers would have borne an estimated time cost of $354.0 million (1996 dollars) with no benefit in return.

On the other hand, using the likely overestimated value of 87 deterred hijackings, each prevented hijacking in 1996 cost that year's passengers approximately $4.0 million dollars (1996 dollars).

What benefits do passengers receive in return for their opportunity cost of the screening measures? To estimate these benefits, it is necessary to imagine the worst scenario for a hijacking: a Jumbo jet was hijacked in 1996 with 350 passengers onboard.

The existing data show that a typical U.S. aircraft hijacking lasts for one day, and that passengers are neither injured nor killed while held hostage.

It is further assumed that the passenger mix inside the hijacked plane reflects the aggregate 1996 mix for air transportation industry passengers reported in Table 10.

The losses for each category of passenger are estimated in the Table below based on the average hourly wage rate for each income bracket.

Income (thousands)	Time Value of One Hour	Number of passengers	Daily Loss per Passenger
More than $50	$24.04	229	$577
$25 to $50	$9.01	87	$216
$0 to $25	$3.00	34	$72

Table 13 - Daily Loss per Passenger Based on Their Time Value for One Hour.

In the Table above, the number of hijacked passengers in each category reflects the percent values in Table 10. The hourly time values were imported from Table 11.

The benefit each passenger receives from airport screening is to avoid the time value losses reported in Table 13. Summing these losses over all passengers implies the total loss per hijacked plane under this scenario is $303,000 (1996 dollars).

If screening procedures prevented 87 fully loaded Jumbo jet hijackings in 1996, the total benefit would have been $26.4 million dollars (1996 dollars). These numbers are very much smaller than the total time value cost of airport screening $354.0 million (1996 dollars) reported above.

Assume that the benefits estimated above are multiplied by 10 to compensate for fear, discomfort, and other inconveniences for the hijacked passengers, as reflected in Table 14. The total estimated benefits -- $264.0 million or $3.0 million per plane -- are still significantly smaller than the passenger's opportunity cost of time associated with airport screening - $354.0 million dollars (1996 dollars).

Income (thousands)	Time Value of One Hour	Number of passengers	Ten times the Daily Loss per Passenger
More than $50	$24.04	229	$5,769
$25 to $50	$9.01	87	$2,163
$0 to $25	$3.00	34	$721

Table 14 - Passenger Estimated Losses Considering Other Inconveniences.

One could argue that the benefits of screening are understated because they take no account of the lives saved that would have been taken during a hijacking. Such an argument is hard to make, however, because the data on hijackings show that no U.S. passenger was ever killed during a domestic hijacking.

Assume, contrary to common sense that in 1996 5 murders did not happen due to prevented hijackings. Even if we set a $10 million value on each life saved, which is the high end of the range economists have found for the value of life people exhibit in their risk-taking behavior (Rosen, p.239), the added benefit from lives saved is still only $50 million dollars. Combining this with the other benefits, which themselves are overestimated, gives a total benefit of $ 76.4 million dollars (1996 dollars). This is still well below $354.0 million, the component of people's time cost due to airport screening.

In conclusion, the opportunity cost of airport screening measures for each of the 1996 passengers is much bigger than the aggregate benefits expected from those measures.

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IV. ANOTHER ISSUE: AIRCRAFT BOMBING

This chapter discusses another kind of illicit interference with commercial aircrafts that is closely related to hijackings: aircraft bombings.

The explosion of TWA flight 800 trigged President Clinton's security tightening measures, even though no evidence of terrorism was ever found.

The first step is to discuss TWA flight 800, including theories about what caused the explosion.

Next, the security tightening measures the Clinton Administration implemented are discussed. The cost of those measures, and the benefits they brought to passengers are estimated. Finally, these costs and benefits are discussed and analyzed.

A. TWA FLIGHT 800

The data used in this section are taken from the article by Fred Bayles and Robert Davis "TWA 800: The mystery remains," (USA Today, July 11th 1997).

On July 17th 1996, at 08:19 PM, TWA flight number 800, a Jumbo jet, departed New York's John Fitzgerald Kennedy Airport for Paris. It carried 230 people, and it had 176,600 pounds of fuel aboard.

The weather was mild and clear. The Jumbo jet was way below its capacity of passengers and fuel. It could hold 433 passengers and crew, and 734,000 pounds of fuel.

The flight continued as usual until 08:31 PM, when it exploded. The explosion showed up on radar screens as multiple blips where it was supposed to have been just one. When the air traffic control station failed to raise TWA 800, it alerted the Federal Aviation Administration (FAA).

The accident investigation started immediately after the catastrophe. Many aircraft parts were recovered, along with most of the bodies of the passengers and crew killed in the crash. The first people to the crash site were fishermen. They found nothing but debris, flames and dead bodies. Many initially concluded that TWA 800 had been bombed. They still remembered what happened to Pan Am 103 over Scotland in 1989.

The only thing known for sure was that the aircraft exploded in the air. According to FBI's Assistant Director Jim Kallstrom, "the chances of this being mechanical are slim, whether it's a 1% or 5%."[16]

16 - Bayles, F. and Davis, R.: "TWA 800: The mystery remains", USA Today, July 11th 1997.

B. POSSIBLE CAUSES OF THE EXPLOSION INSIDE TWA 800

The investigation into this explosion was frustrating. Much of the aircraft's structure and components were recovered. However, no conclusive evidence was found to support any of the probable causes for the explosion that tore TWA 800 apart and killed all its occupants.

When the cockpit voice recorders were found, there was some hope that they could shed light on the causes of this terrible catastrophe. But even these recorders, the famous "black boxes," failed to explain the explosion.[17]

In this section, some of the possible causes for this explosion are discussed. The possibilities reported here have some basis in the evidence to date. The evidence, however, is not strong enough to verify any of these possibilities as a clear-cut cause for explosion of TWA 800.

1. Bomb

According to Bayles and Davis,[18] on July 22nd 1996 investigators privately admitted that explosive residues were found on the wreckage. On July 24th 1996, some "sources" told the two journalists that silver metal chips were found in some of the bodies and debris of the downed airplane. However, James K. Kallstrom, FBI Assistant

17 - The same as footnote 16.

18 - The same as in footnote 16.

Director, told Aviation Week and Space Technology[19] that FBI agents interviewed the crew that worked on the last flight in the 747 before the plane was assigned to flight 800. They also interviewed all the people that worked around or on the plane between flights. According to him, no evidence of criminal activity was found.

According to Kallstrom,[20] tests were performed for bomb chemical residues in the recovered structure parts, debris, and passenger luggage. Again, he concluded that no evidence was found to support the suspicion of criminal activity.

2. Missile hit

The missile theory drew some attention when a reporter for CBS television[21] obtained two stained seat fabric pieces from TWA 800. That reporter had the stains tested in an independent laboratory. The test showed that the reddish substance staining the fabric was associated with rocket missile fuel.[22]

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19 - McKeena, James T.: "FBI Details TWA 800 Criminal Probe", Aviation Week and Space Technology, November 24th 1997.

20 - The same as in footnote 19.

21 - Wolper, Allan: "The FBI convinced CBS" :Editor & Publisher, May 17th 1997.

22 - Wolper, Allan: "Source or journalism?", Editor & Publisher, May 17th 1997, NY.

If the explosion of TWA 800 was really caused by a missile hit, that missile could have had two possible origins: terrorism, and a U.S. military missile launched by any of the warships, military airplanes or submarines conducting exercises in that area.

In his interview for Aviation Week and Space Technology,[23] FBI Assistant Director James Kallstrom said that the FBI had no reports of suspicious activities, or of missing or abandoned boats along Long Island's south coast, for weeks before and after TWA 800 exploded. Nothing was found to support the terrorism theory.

In the same interview, Kallstrom also stated that the FBI did not find evidence to support the military missile hit theory. According to him, FBI agents interviewed crew from every ship, plane or submarine operating within two hundred miles of the point where flight 800 exploded. The reports of those interviews were unanimous: no missile was launched. Most of those interviewed claimed that flight 800 was out of range for any of their weapons when it exploded.

In the interview for Aviation Week and Space Technology,[24] Kallstrom reported that FBI agents also checked the possibility that a drone hit the 747. After

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23 - The same as in footnote 19.

24 - The same as in footnote 19.

extensive research, it was concluded that "There were no drones in the air."

3. Electromagnetic interference

According to Elaine Scarry,[25] the electromagnetic interference theory arose from conversations recorded by the "black boxes." In these conversations, the pilot mentioned problems with fuel flow, and that control surfaces (flaps) had deployed without command. According to Scarry, these are characteristic signals of ongoing electromagnetic interference.

The author theorizes a possible interference of electromagnetic emissions of military aircrafts or warships in the vicinity of flight 800 and the 747's electronic systems, and its "fly-by-wire" flight control system.

According to Scarry, "Until the relevant information about the electronic equipment used on the night of July 17th 1996, and the relevant Air force and Pentagon studies, are made public, we simply won't know."[26]

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25 - Scarry, Elaine: "The fall of TWA 800: The possibility of electromagnetic interference", The New York Review of Books, April 9th 1998, NY.

26 - The same as in footnote 25.

4. Fuel vapor explosion inside the center fuel tank

James T. McKenna[27] reported that the cockpit voice recorders detected the explosion of the center fuel tank right before the equipment stopped recording.

It was then theorized that the center tank exploded by igniting overheated fuel vapors trapped inside the center tank.

Reporting on the investigation into TWA 800, Bayles and Davis[28] wrote that Boeing conducted tests on another 747 under the same conditions as TWA 800. The reporters stated that the engineers who conducted the tests found that the tank was hotter than they expected.

Continuing their report, Bailes and Davis wrote that when the results of Boeing's test were known, the National Transportation Safety Board (NTSB) urgently required that FAA get rid of the explosive vapors inside the fuel tanks. Later, on June 27th 1997, the NTSB and FAA issued recommendations for "what should be done to change airline jet fuel systems."[29]

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27 - The same as in footnote 19.

28 - The same as in footnote 16.

29 - The same as in footnote 16.

Summarizing the TWA investigation, James Kallstrom stated, "We don't have piles of evidence. What we have are piles of competing speculation."[30]

Today, almost three years after the accident, the different theories about the explosion onboard TWA 800 still are being discussed.

Gunwald[31] reports that, until November 1997, the FBI tried to keep its investigation focused on the hypothesis that a bomb or a missile hit caused TWA 800 to explode. According to Gunwald:

> It wasn't until November 1997 that the FBI acknowledged publicly that a mechanical flaw indeed ignited the Boeing 747's central fuel tank, a concession that finally put pressure on airlines to begin correcting the problem. For months, documents suggest, the bureau had stuck to its sabotage theory -- despite private protests by the ATF, the national Transportation Safety Board, the Central Intelligence Agency and even some of its own scientists.

It is Gunwald's opinion that a never released report by ATF -- Bureau of Alcohol, Tobacco and Firearms -- is likely to play a major role in that Senate hearing.

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30 - The same as in footnote 16.

31 - Gunwald, Michael: "Agencies dispute cause of air crash", Monterey Herald, May 9th, 1999.

C. PRESIDENT CLINTON'S SECURITY MEASURES

About a week after TWA flight 800 exploded, on July 25th 1996, President Clinton made a statement on air safety. While asking the American people "not to jump to conclusions," the president made the following announcement:

> I have ordered the Secretary of Transportation to issue new directives on airline security that cover international and domestic flights, and apply to passengers and to cargo. From now on, we will hand-search more luggage and screen more bags. And we will require preflight inspections for any plane flying to or from the United States -- Every plane, every cabin, every cargo hold, every time.[32]

Continuing his statement, President Clinton informed:

> I have asked Vice President Gore to take charge of a commission to review aviation safety, security and the pace of the modernization of the Air Traffic Control System -- a subject that he and his Reinventing Government Task force have been working on for more than three years now.[33]

As an immediate result of President Clinton's speech, the FAA tightened existing airline passenger search and screening measures.

Along with these immediate steps, Vice President Gore's commission proposed other security measures to increase flight safety. Vice President Gore's commission estimated

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32 - Clinton, William J.: "Statement by the President on Air Safety", The White House Office of the Press Secretary, July 25th 1996, NY.

33 - The same as in footnote 32.

that the total cost of these additional measures would be $1.1 billion dollars. The measures directly aimed at airport safety were estimated to cost $360.4 million dollars.[34]

The proposed measures that directly affected airport security were:[35]

- $91.1 million to install 54 luggage screening machines that can detect plastic explosives.
- $37.8 million for equipment capable of detecting explosive traces on carry-on luggage, laptops, and cellular phones.
- $31.4 million for the X-rays and other explosives detection devices for international air cargo.
- $26.6 million to allow U.S. Custom officials to check the U.S. mail transported on international flights.
- $146.6 million to increase the FBI's anti-terrorism activities.
- $18 million to increase the FAA's workforce.
- $8.9 million for training and deploying bomb sniffing dogs.

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34 - Lane, E: "$1.1B Requested to combat terror", NEWSDAY.com, September 10th 1996, URL: http://www.newsday.com/jet/twamain.htm.

35 - The same as in footnote 34.

The remainder of the proposed $1.1 billion dollars was to be spent in areas other than aviation security. These other areas included U.S. facilities overseas, troop positioned in the Persian Gulf, infectious disease laboratories, and other public facilities in the United States.[36]

It is logical to think that implementing the above-specified measures will increase the cost of air transportation. In consequence, it is also logical to think that air transportation organizations will pass along to users the part of the increased cost at least to the extent that market elasticity allows.

D. COST OF THOSE MEASURES IN TERMS OF PASSENGER TIME VALUE

The impact of the tightened security measures on passengers' waiting time is two fold: time lost at both check-in and baggage claim. The first effect is the time lost in line at the check-in ask ticket agents as each passenger about their control over their carried luggage.

Assuming that it takes each passenger twenty seconds to answer the clerk's questions, and that there are on average ten people in line after that person, it is possible to estimate the average increase in time due to check-in questions. The numbers are reported in Table 15 below.

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36 - The same as in footnote 34.

Person order in the check-in line	Delay (seconds)
At the counter	20
First in line	40
Second in line	60
Third in line	80
Forth in line	100
Fifth in line	120
Sixth in line	140
Seventh in line	160
Eighth in line	180
Ninth in line	200
Tenth in line	220

Total delay of the line (seconds)	1320
Average delay (seconds)	120
Average delay (minutes)	2

Table 15 - Passenger Delay Due to Check-In Questions.

Assume a check-in situation in which there is a passenger at the counter and ten others in line. Assume further that no other passenger will enter this line until all waiting passengers have been served. If the person at the check-in counter spends 20 seconds answering the luggage security questions, that person will be delayed by 20 seconds. The first person in line will be delayed by these 20 seconds, plus the 20 seconds it takes him or her to answer the security questions, or 40 seconds in total. By similar reasoning, the cumulative total increases by 20 seconds for each successive person in line.

Adding together all delays and dividing the total by eleven, the average delay for the eleven people depicted in Table 14 is 120 seconds, or two minutes.

The second impact of tightened security measures involves delays when passengers are waiting to pick up their baggage from the baggage claim carousels.

Assuming that luggage security procedures will delay each passenger by an additional two minutes on average, these tightened security measures cost each passenger four minutes of time.

Chapter Three calculated the average time value for air transportation passengers in 1996. Using that value and the four-minute delay estimated above, the increased airport security measures that the Clinton Administration proposed in 1996 would have imposed a $920.8 million dollar time value cost on airline passengers in 1996.

E. BENEFITS VERSUS COSTS

As of this writing, the last confirmed American flag airliner destroyed in a terrorist attempt was Pan Am 103 over Lockerbie, Scotland, in 1989. This terrorist attack claimed two hundred and seventy victims; it is still a very bad memory, especially for those who lost family or friends in the tragedy.

In the opinion of retired Rear Admiral Cathal "Irish" Flynn, who became FAA's Chief of security in 1993: "The records indicate that people were much more secure in the

decade since Pan Am 103" He continues: "It isn't something that one points to with pride. It's just a fact."[37]

Others agree that security has improved since Pan Am 103. However, they think that there are holes in security that terrorists could still exploit. Bob Moretti is among those who think that security still has "giant holes."[38]

Moretti lost his son on Pan Am 103. Now he is a part-time consultant for the FAA. He, and others like him, believe that risks continue because of uneven passenger and carry-on bag screening, ineffective use of explosive-detection devices, and the lack of a program to match bags to domestic passengers.[39]

The explosion of TWA 800 created the emotional momentum to introduce new flight security measures.[40] However, nobody has been able to prove that TWA 800 was victim of a terrorist bomb.

When TWA 800 exploded, air transportation passengers already bore the burden of passenger and luggage screening

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37 - Levin, Alan: "Aviation Upgrades a work in progress security better but holes remain 10 years after Pan Am 103 explosion", USA Today, December 18th 1998.

38 - The same as in footnote 37.

39 - The same as in footnote 37.

40 - The same as in footnote 37.

procedures. The Clinton Administration not only tightened those measures, but also introduced new ones.

Adding the $354.0 million dollars (1996 dollars) estimated opportunity cost for passengers of the screening measures together with the $920.8 million dollars opportunity cost of the Clinton Administration measures, the total opportunity cost of airport security measures in 1996 is equal to approximately $1.3 billion dollars (1996 dollars).

Considering the uncertainty about what destroyed TWA 800, the additional cost of 1996 measures to American passengers appear to be much higher than the additional benefits they brought to them.

If the costs of Vice President Gore commission's recommended measures exceed its benefits, it is important to ask why the federal government implemented the policy.

One reasons for adopting these costly measures could have been the government's preoccupation with President Clinton's reelection. According to Newsday's Earl Lane:

> While investigators have been unable to determine if that crash in the waters off Long island was caused by sabotage, the White house has been anxious in an election year to demonstrate that it is taking action against even perceived increase in threats to U.S. air travelers.[41]

41 - the same as in footnote 34.

Considering the high opportunity costs to passengers of increasing airport security, the cost of the new policies appears to be well above their benefits.

V. CONCLUSION

This thesis analyzes government policies concerning airport security measures. This chapter highlights its major findings.

The extra time passengers spend waiting to go through airport screening procedures has a value to those passengers, and aggregate passenger's time costs can be significant. Assuming that passengers in 1996 waited two minutes on average to go through airport security measures, the opportunity cost of their time value was estimated to be $354.0 million dollars per year (1996 dollars).

One of the main goals of airport screening procedures is to prevent hijackings. When applying 1996 data to the regression model used in this thesis, the predicted number of hijackings considering and not considering the impact of passenger screening was almost the same. The mentioned results suggested that screening deterred no hijacking in 1996. If zero hijackings were prevented, 1996 passengers bore a cost of $354.0 million dollars (1996 dollars) in terms of their time value, but obtained no benefit from it.

Another way of estimating the number of prevented hijackings is to assume that passenger screening is very effective. To do this, it is necessary to assume that

hijackings would have increased proportionally to the growth of passengers if screening procedures had not been in place in 1996. Under these assumptions, it was estimated that 87 hijackings deterred in 1996. This number is likely to be a grossly overestimated.

If 87 hijackings were prevented in 1996, the prevention of each one cost that year's passengers $4.0 million dollars (1996 dollars) in terms of their time value.

The worst case scenario -- a hijacked Jumbo jet with 350 people onboard -- was used in this thesis to estimate the minimum average loss per passenger that would justify the estimated cost to prevent a hijacking. The available data indicated that a typical hijacking in the U.S. lasted for 24 hours and that no passenger were killed or injured while held hostage.

If no hijacking was prevented in 1996, that year's passengers bore a cost of $354.0 million dollars (1996 dollars), but had no benefit in exchange.

If 87 hijackings were prevented, the opportunity cost for passengers per hijacking prevented is $4.0 million dollars (1996 dollars).

On the other hand, the maximum time value benefit for a 350-passenger hijacked Jumbo jet is $303,000. This number is

much smaller than the time value costs of either case above -- $354.0 million and $4.0 million (all in 1996 dollars).

The estimated time value losses for the hijacked passengers are much smaller than the estimated benefit of preventing a hijacking. This difference does not justify any investment in pre-flight screening measures.

In 1996, after the explosion on TWA flight 800, the Clinton Administration adopted several measures to tighten airport security. These measures were implemented even though the TWA 800 investigation never determined what caused the explosion, including terrorism.

President Clinton's measures further increased passenger waiting time costs. If President Clinton's security tightening measures delay each passenger for four minutes, they create yearly passenger time value losses that total $920.8 million dollars (1996 dollars).

The total yearly passenger time cost of airport security measures was estimated at $1.3 billion dollars (1996 dollars) in 1996.

This thesis showed that the costs of airport security measured in terms of passengers' time value are much higher than their estimated benefits.

Finally, airport security passenger time value costs can be updated in the future, and the scope expanded to

consider the costs of other security policies the federal government could have adopted. Future studies can estimate the costs and the benefits of airport security applied to "what if" situations, which are outside the scope of this thesis.

APPENDIX A. MONTHLY DATA FOR THE REGRESSION ANALYSIS

Year	Month	Time	Hijackings	Passengers	Departures	Miles Flown	Treaty	Screening
1961	JAN	1	0	4,829	305,600	76,787	0	0
	FEB	2	0	3,869	249,975	59,157	0	0
	MAR	3	0	5,107	314,814	78,171	0	0
	APR	4	0	5,274	311,634	77,716	0	0
	MAY	5	1	5,241	325,001	80,648	0	0
	JUN	6	0	5,901	332,103	84,067	0	0
	JUL	7	0	5,568	337,170	86,049	0	0
	AUG	8	0	5,956	343,924	87,131	0	0
	SEP	9	0	5,383	317,740	81,876	0	0
	OCT	10	0	5,510	319,979	83,261	0	0
	NOV	11	0	5,199	302,155	79,004	0	0
	DEC	12	0	5,165	290,230	77,659	0	0
1962	JAN	13	0	5,413	301,315	80,632	0	0
	FEB	14	0	4,912	272,762	73,781	0	0
	MAR	15	0	5,658	317,455	85,137	0	0
	APR	16	1	5,867	313,994	83,453	0	0
	MAY	17	0	5,819	327,286	87,097	0	0
	JUN	18	0	6,123	313,089	85,380	0	0
	JUL	19	0	5,568	297,667	80,757	0	0
	AUG	20	0	6,161	308,176	84,193	0	0
	SEP	21	0	5,754	300,240	82,962	0	0
	OCT	22	0	5,827	320,325	86,836	0	0
	NOV	23	0	5,424	298,692	80,896	0	0
	DEC	24	0	5,287	290,251	81,886	0	0
1963	JAN	25	0	5,694	300,924	85,763	0	0
	FEB	26	0	5,209	300,202	78,576	0	0
	MAR	27	0	6,014	311,833	87,554	0	0
	APR	28	0	6,388	314,322	87,258	0	0
	MAY	29	0	6,313	328,319	91,344	0	0
	JUN	30	0	7,089	322,694	92,284	0	0
	JUL	31	0	6,794	331,606	95,287	0	0
	AUG	32	0	7,474	336,236	96,177	0	0
	SEP	33	0	6,643	316,528	91,598	0	0
	OCT	34	0	6,938	317,462	94,201	0	0
	NOV	35	0	6,226	306,189	88,721	0	0
	DEC	36	0	6,624	312,134	91,958	0	0
1964	JAN	37	0	6,714	318,552	92,871	0	0
	FEB	38	1	6,288	305,175	88,594	0	0
	MAR	39	0	7,043	327,303	94,801	0	0
	APR	40	0	7,052	319,953	92,414	0	0

Year	Month	Time	Hijackings	Passengers	Departures	Miles Flown	Treaty	Screening
1964	May	41	0	7,224	335,150	97,237	0	0
	JUN	42	0	7,970	336,575	99,824	0	0
	JUL	43	0	7,870	349,378	100,523	0	0
	AUG	44	0	8,334	349,476	105,034	0	0
	SEP	45	0	7,531	331,957	100,650	0	0
	OCT	46	0				0	0
	NOV	47	0				0	0
	DEC	48	0				0	0
1965	JAN	49	0	7,660	326,437	102,995	0	0
	FEB	50	0	6,864	300,880	94,919	0	0
	MAR	51	0	7,866	341,631	107,713	0	0
	APR	52	0	8,406	338,180	102,902	0	0
	MAY	53	0	8,351	355,330	111,290	0	0
	JUN	54	0	9,216	358,472	113,351	0	0
	JUL	55	0	9,347	370,562	118,788	0	0
	AUG	56	1	9,994	376,872	120,930	0	0
	SEP	57	0	8,857	353,968	114,309	0	0
	OCT	58	2	9,003	365,436	117,918	0	0
	NOV	59	1	8,319	346,178	111,274	0	0
	DEC	60	0				0	0
1966	JAN	61	0	8,995	357,645	118,597	0	0
	FEB	62	0	8,263	329,530	109,691	0	0
	MAR	63	0	9,718	374,242	123,938	0	0
	APR	64	0	10,548	370,603	122,585	0	0
	MAY	65	0	10,330	387,593	129,125	0	0
	JUN	66	0	11,529	387,572	131,804	0	0
	JUL	67	0	8,258	298,268	103,595	0	0
	AUG	68	0	8,760	320,216	98,400	0	0
	SEP	69	0	10,469	387,410	134,217	0	0
	OCT	70	0	10,544	397,014	137,695	0	0
	NOV	71	0	10,024	376,654	130,564	0	0
	DEC	72	0	10,628	385,855	136,771	0	0
1967	JAN	73	0	10,513	383,005	136,239	0	0
	FEB	74	0	9,493	354,034	125,568	0	0
	MAR	75	1	11,875	405,185	143,443	0	0
	APR	76	0	11,318	396,839	141,033	0	0
	MAY	77	0	11,383	418,449	149,562	0	0
	JUN	78	0	13,163	419,201	151,688	0	0
	JUL	79	0	12,935	434,134	160,451	0	0
	AUG	80	0	14,126	446,858	165,199	0	0
	SEP	81	0	12,048	422,448	158,118	0	0
	OCT	82	0	11,989	433,209	162,547	0	0
	NOV	83	0	11,382	410,862	155,305	0	0
	DEC	84	0	12,293	421,988	164,430	0	0

Year	Month	Time	Hijackings	Passengers	Departures	Miles Flown	Treaty	Screening
1968	JAN	85	0	11,963	420,859	165,356	0	0
	FEB	86	3	11,396	407,169	156,560	0	0
	MAR	87	2	12,936	435,294	169,484	0	0
	APR	88	0	13,514	435,636	168,706	0	0
	MAY	89	1	13,014	446,703	176,550	0	0
	JUN	90	0	15,039	444,474	178,605	0	0
	JUL	91	5	14,785	463,129	187,319	0	0
	AUG	92	2	16,354	518,681	191,248	0	0
	SEP	93	1	13,229	445,126	182,420	0	0
	OCT	94	1	13,403	459,383	186,587	0	0
	NOV	95	5	12,308	430,171	176,129	0	0
	DEC	96	3	14,222	441,409	184,116	0	0
1969	JAN	97	9	13,248	428,304	183,904	0	0
	FEB	98	4	11,836	397,001	166,860	0	0
	MAR	99	4	13,945	437,297	179,183	0	0
	APR	100	1	14,492	450,142	190,294	0	0
	MAY	101	3	14,322	462,513	197,666	0	0
	JUN	102	4	15,880	459,279	200,644	0	0
	JUL	103	2	15,971	471,709	209,857	0	0
	AUG	104	4	17,170	463,129	208,304	0	0
	SEP	105	3	13,742	458,180	205,566	0	0
	OCT	106	3	13,950	467,467	211,665	0	0
	NOV	107	1	12,909	435,046	198,866	0	0
	DEC	108	2	14,425	449,093	208,832	0	0
1970	JAN	109	2	13,830	446,879	211,043	0	0
	FEB	110	1	12,145	387,889	184,639	0	0
	MAR	111	2	14,261	431,219	200,323	0	0
	APR	112	2	13,299	406,397	187,419	0	0
	MAY	113	2	14,140	435,672	203,910	0	0
	JUN	114	2	15,486	448,968	211,380	0	0
	JUL	115	1	16,009	452,850	205,912	0	0
	AUG	116	5	16,834	446,862	201,649	0	0
	SEP	117	5	13,687	425,897	191,200	0	0
	OCT	118	1	13,385	427,986	194,971	0	0
	NOV	119	2	12,663	397,329	183,574	0	0
	DEC	120	2	14,150	408,506	191,388	0	0
1971	JAN	121	2	13,497	402,649	190,235	0	0
	FEB	122	2	12,017	366,367	173,795	0	0
	MAR	123	3	13,627	416,158	195,170	0	0
	APR	124	2	14,947	412,475	190,115	0	0
	MAY	125	2	14,195	425,193	196,713	0	0
	JUN	126	3	14,129	426,146	197,195	0	0
	JUL	127	3	16,233	440,573	205,551	0	0
	AUG	128	0	16,886	444,838	207,310	0	0

Year	Month	Time	Hijackings	Passengers	Departures	Miles Flown	Treaty	Screening
1971	SEP	129	2	13,894	417,617	194,572	0	0
	OCT	130	4	14,423	425,219	194,923	0	0
	NOV	131	1	13,600	407,569	185,200	0	0
	DEC	132	2	14,299	416,766	192,767	0	0
1972	JAN	133	5	14,805	410,252	192,689	0	0
	FEB	134	0	13,496	388,462	181,542	0	0
	MAR	135	3	15,811	427,749	197,107	0	1
	APR	136	6	15,831	417,010	191,923	0	1
	MAY	137	2	15,572	434,846	198,931	0	1
	JUN	138	4	17,008	429,045	199,808	0	1
	JUL	139	7	17,546	429,632	198,851	0	1
	AUG	140	1	18,626	436,867	201,148	0	1
	SEP	141	0	15,207	409,080	188,359	0	1
	OCT	142	1	15,837	430,348	197,015	0	1
	NOV	143	1	15,254	413,550	187,625	0	1
	DEC	144	0	16,360	419,941	195,066	0	1
1973	JAN	145	1	15,673	437,682	203,074	0	1
	FEB	146	0	14,353	395,844	184,386	1	1
	MAR	147	0	16,740	439,066	205,995	1	1
	APR	148	0	16,981	426,725	200,901	1	1
	MAY	149	0	16,726	429,643	204,960	1	1
	JUN	150	0	18,035	429,326	207,339	1	1
	JUL	151	1	18,559	457,548	219,879	1	1
	AUG	152	0	19,970	466,155	223,834	1	1
	SEP	153	0	15,950	432,893	206,366	1	1
	OCT	154	0	16,540	444,684	208,804	1	1
	NOV	155	0	16,141	386,880	170,202	1	1
	DEC	156	0	16,553	387,587	174,999	1	1
1974	JAN	157	0	16,295	379,349	176,856	1	1
	FEB	158	1	15,285	344,595	160,595	1	1
	MAR	159	1	18,276	394,309	183,406	1	1
	APR	160	0	18,085	387,252	178,801	1	1
	MAY	161	1	17,671	400,750	186,767	1	1
	JUN	162	2	18,744	402,959	190,294	1	1
	JUL	163	0	18,790	416,938	198,930	1	1
	AUG	164	0	20,189	417,795	199,429	1	1
	SEP	165	1	15,850	389,334	184,092	1	1
	OCT	166	0	16,594	403,707	188,122	1	1
	NOV	167	0	14,919	389,854	182,117	1	1
	DEC	168	1	16,758	399,869	189,974	1	1
1975	JAN	169	2	15,763	390,481	190,273	1	1
	FEB	170	0	14,276	357,765	169,167	1	1
	MAR	171	2	17,231	396,307	186,344	1	1

Year	Month	Time	Hijackings	Passengers	Departures	Miles Flown	Treaty	Screening
1975	APR	172	1	16,086	387,272	178,472	1	1
	MAY	173	1	16,726	401,091	186,306	1	1
	JUN	174	1	18,397	401,503	189,792	1	1
	JUL	175	0	19,064	420,208	199,530	1	1
	AUG	176	1	20,435	417,609	198,325	1	1
	SEP	177	1	16,120	385,964	181,117	1	1
	OCT	178	1	17,396	397,116	184,057	1	1
	NOV	179	2	16,135	371,157	172,868	1	1
	DEC	180	0	17,388	366,088	165,334	1	1
1976	JAN	181	0	17,095	393,290	185,107	1	1
	FEB	182	0	16,387	374,699	175,538	1	1
	MAR	183	0	16,403	405,160	190,972	1	1
	APR	184	1	18,804	397,709	186,055	1	1
	MAY	185	1	19,512	404,499	189,210	1	1
	JUN	186	0	19,713	409,780	193,897	1	1
	JUL	187	0	20,830	427,554	204,427	1	1
	AUG	188	0	21,417	430,043	205,557	1	1
	SEP	189	1	17,663	399,256	189,962	1	1
	OCT	190	0	18,318	404,159	191,529	1	1
	NOV	191	0	17,172	380,715	177,494	1	1
	DEC	192	1	19,031	408,495	193,146	1	1
1977	JAN	193	2	18,413	401,330	193,975	1	1
	FEB	194	0	16,684	373,452	177,924	1	1
	MAR	195	0	19,985	415,841	198,552	1	1
	APR	196	0	19,654	405,309	192,622	1	1
	MAY	197	1	19,460	413,855	196,971	1	1
	JUN	198	0	20,795	416,776	202,456	1	1
	JUL	199	0	22,278	432,501	212,247	1	1
	AUG	200	1	23,075	438,396	214,840	1	1
	SEP	201	0	19,289	406,513	199,148	1	1
	OCT	202	1	20,300			1	1
	NOV	203	0	19,389	398,712	191,643	1	1
	DEC	204	1	21,004	413,434	202,180	1	1

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APPENDIX B. 1996 MONTHLY DATA FOR THE REGRESSION ANALYSIS

Year	Month	Time	Hijackings	Passengers	Departures	Miles Flown	Treaty	Screening
1996	JAN	205	0	41,135	456,400	659,151	1	1
	FEB	206	0	49,283	432,825	645,578	1	1
	MAR	207	0	51,284	450,233	703,919	1	1
	APR	208	0	48,106	452,745	579,541	1	1
	MAY	209	0	48,339	487,907	697,427	1	1
	JUN	210	0	50,845	464,585	678,220	1	1
	JUL	211	0	52,189	484,299	700,516	1	1
	AUG	212	0	54,188	469,275	710,415	1	1
	SEP	213	0	45,323	488,825	667,243	1	1
	OCT	214	0	48,989	466,778	694,284	1	1
	NOV	215	0	44,320	448,503	656,695	1	1
	DEC	216	0	46,928	473,665	685,784	1	1

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